Claims

I claim:

1. A method for decoding an $[N,k]_q$ sparse transform factor graph code using a soft-input cost function, comprising:

a one-time initialization procedure; comprising:

constructing a sparse transform factor graph representation of the code;

selecting an encoding method consistent with the representation;

selecting a message-passing decoder method consistent with the representation;

initializing messages of the selected decoder method according to the soft-input cost function; and

an iterative decoding procedure, comprising:

updating messages according to message-update rules of the selected decoder;

outputting a code word when a termination condition is true, and

otherwise repeating the iteration of the decoding procedure.

2. The method of claim 1, in which the code is a Reed-Solomon code.

3. The method of claim 1, in which the code is an extended Reed-Solomon code.

4. The method of claim 1, in which the code is a punctured Reed-Solomon code.

5. The method of claim 1, in which the code is a extended ternary Golay code.

6. The method of claim 1, in which the code is a non-binary code.

7. The method of claim 1, in which the sparse transform factor graph includes input-output factor nodes, each input-output factor node has k input variables entering the node from the left, and k output variables exiting the node from the right, and the input variables and the output variables are related by $2k$ constraints, where k is a rank of the input-output factor node.

8. The method of claim 7, in which the rank k is two.

9. The method of claim 7, further comprising:

stacking and layering the input-output factor nodes.

10. The method of claim 1, wherein the sparse transform factor graph code is a fast sparse transform factor graph code.

11. The method of claim 1, further comprising:

simplifying the sparse transform factor graph representation.

12. The method of claim 11, further comprising:

generating a plurality of the simplified sparse transform factor graph representations; and

combining the plurality of the simplified sparse transform factor graph representations into a redundant sparse transform factor graph representation.

13. The method of claim 1, in which the message passing decoding method includes message-update rules and belief-update rules.

14. The method of claim 1, in which the messages are initialized to zero.

15. The method of claim 1, in which the iterative decoding procedure further comprises:

determining a trial code word from the messages, the selected decoder method and the encoding method;

determining a cost of the trial code word using the soft-input cost function;

updating a tentative code word with the trial code word if the trial code word has lower cost than the tentative code word; and

terminating by outputting the tentative code word when the termination condition is true, and otherwise repeating the iteration of the decoding procedure.

16. The method of claim 15, in which an initial cost of the tentative code word is infinity.

17. The method of claim 15, in which the termination condition is fixed number of iterations.

18. The method of claim 1, further comprising:

combining the selected decoder with a with a different decoder.

19. The method of claim 1, further comprising:

combining the selected decoder with a hard-input bounded-distance decoder that uses thresholding.

20. The method of claim 1, further comprising:

concatenating the selected decoder with a different soft-input decoder.

21. The method of claim 10, in which the fast sparse transform factor graph has M q-ary input and output variables, and where N input, internal, and output transform variables in the fast sparse transform factor graph are connected to soft-constraint factor nodes, and M-k of the input variables are connected to factor nodes that constrain the input variables to equal zero.

22. The method of claim 21, in which the fast sparse transform factor graph includes hard-constraint equality constraint factor nodes to copy the internal transform variables that are connected to the soft-constraint factor nodes.